Washington University School of Medicine
Mechanical Design Standards

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SECTION 15720 – AIR HANDLING UNITS

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. Layout shall be arranged to facilitate air handling maintenance including coil cleaning, coil replacement and filter replacement. Where coil connection sizes are smaller/larger than the line sizes associated with the system piping, a reducer/increaser shall be installed immediately at the coil flanges to adapt to the indicated line size. All specialties and service valves associated with the coil piping shall be line size, and not coil connection size.

B. On the drawings indicate the required service clearance, including coil replacement pull space, filter replacement pull space, fan/motor replacement pull space, and access to all inspection doors and maintenance points.

C. The designer shall locate the equipment such that it can be replaced at the end of its life without removing building structural components. (i.e. provide area ways, louvers, removable panels, doors, etc.)

D. Each coil shall have upstream and down stream access for inspection and cleaning.

E. Piping design shall locate flanges/unions and service valves to allow removing the coil by removing a minimal amount of piping.

F. Humidifiers are to be used only when requested by the Owner. When a humidifier coil is used it shall be located in an access section with a drain pan located up stream of the cooling coil. Trim humidifiers located in the ductwork shall have drain pans installed 2 times the absorption distance downstream of the humidifier.

G. Units shall be draw through arrangement.

H. Cooling coil face velocity shall not exceed 500 fpm.

I. 24” x 24” Filter sizes are preferred, use external filter section when necessary. Filter face velocity shall not exceed 400 fpm. Filtration for Academic, Office, and Residential buildings shall be 30% efficient (MERV 7) on ASHRAE Test Standard 52, unless otherwise directed by the Owner.

J. Designer shall calculate the condensate trap height for each unit, indicate additional supporting steel where condensate trap height is greater than the height available from the unit base rails and housekeeping pad.

K. Energy Recovery wheels shall have the following minimum characteristics:

   1. Aluminum substrate
   2. Aluminum support system
   3. Modular Media sections
   4. 3Angstrom molecular sieve desiccant
   5. External pillow block bearings
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6. Non-wearing seals
7. Tested in accordance with ASHRAE 84

L. Units shall have the following minimum characteristics:

1. Double Wall, insulated, galvanized steel
2. Air foil or backward inclined fans
3. Internally seismic isolated fans
4. Coils – ½" diameter x .020" wall thickness copper tubes and .0075"
   aluminum or copper fins spaced not closer than 10 per inch
5. Chilled water coils shall not be less than 6 rows
6. Stainless steel cooling coil casing
7. Stainless steel drain pans, IAQ double pitched
8. Intermediate drain pans for stacked cooling coils
9. Stacked coils shall have independent coil frames
10. Extended tube lines through the unit casing
11. Hinged access doors with quarter turn handles
12. NEMA premium efficiency motor
13. Inverter rated motor when used with VSD
14. NEMA starters, if furnished with unit.
15. Marine lights with 1 hour timer switch in units larger than 15,000 cfm
16. Stainless steel fan shafts in units larger than 15,000 cfm

M. Large roof mounted equipment shall have the following additional characteristics:

1. Walk-in sections or service vestibule
2. Marine lights with 1 hour timer switch
3. Rain gutters
4. Electrical receptacles

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS

A. Packaged – Trane, York, Carrier, McQuay

B. Custom – Air Enterprise, Buffalo, Webco, Marcraft

2.2 SPECIFICATIONS

A. Specify that the manufacturer shall use the most energy efficient fan option within
   the manufacturer’s line for the unit size but in no case will the wheel be smaller
   than the diameters scheduled.

B. Specify that water coil connections are copper or brass.

C. Specify that energy recovery wheels be manufactured by SEMCO.
SECTION 233600 - AIR TERMINAL UNITS

PART 1 - PROGRAMMING AND DESIGN GUIDELINES

1.1 SUMMARY

A. Section Includes:

   1. Single-duct air terminal units.
   2. Dual-duct air terminal units.

1.2 DESIGN REQUIREMENTS

A. For terminal units with reheat coils, duct and piping insulation shall be installed continuous on all exterior surfaces of reheat coils to prevent sweating when the reheat coil is not activated.

B. Terminal units shall be designed to facilitate maintenance. Design with a minimum of 24 inches of clearance from the building automation enclosure mounted on the side of the box. Drawings shall indicate the location of the control enclosure and shall also illustrate that the clearance requirement be maintained.

C. Terminal units shall be specified with a minimum of 36” of straight duct (flexible duct is not permitted) upstream of the terminal units. Ductwork shall be the same size as the terminal box inlet.

D. Terminal units shall be specified with a factory installed access door to enable viewing of the damper(s) and inlet of the reheat coil face.

E. Internal liner within terminal units shall be foil faced.

F. The use of double duct terminal units are discouraged. Where required, double duct terminal units shall be specified with mixing sections to encourage mixing.

G. The use of fan-powered terminal units are discouraged. Where required, provisions must be made to filter plenum air intake to fan-powered terminal units.

PART 2 - BIDDING AND CONTRACT DOCUMENT REQUIREMENTS

2.1 MANUFACTURERS

A. Terminal units shall be as manufactured by Titus, Krueger or Tuttle and Bailey.
2.2 BUILDING AUTOMATION

A. Direct digital controls shall be provided on all terminal units. Pneumatic controls shall not be acceptable.

2.3 SINGLE-DUCT AIR TERMINAL UNITS

A. Configuration: Damper and flowmeter assembly inside unit casing with control components inside a protective metal shroud.

B. Casing: No less than 22 gauge welded, galvanized steel, single wall.

   1. Casing Lining: Adhesive attached, 1-inch thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

      a. Cover liner with nonporous foil.

   2. Air Inlet: Round stub connection for duct attachment.

   3. Air Outlet: S-slip and drive connections.

   4. Airflow Meter: Provide a multiple point averaging flow sensing ring with high and low pressure pneumatic tubes compatible with DDC velocity pressure sensor. A calibration chart shall be mounted on each terminal unit.

   5. Access: Removable panels for access to diverting damper and other parts requiring service, adjustment, or maintenance; with airtight gasket.

C. Damper Assembly: Heavy gauge steel blades with solid steel shaft, with nylon-fitted pivot points.

D. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 12 fins per inch, and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F.

2.4 DUAL-DUCT AIR TERMINAL UNITS

A. Configuration: Two volume dampers inside unit casing with mixing section and control components inside a protective metal shroud.

B. Casing: No less than 22 gauge welded, galvanized steel, single wall.

   1. Casing Lining: Adhesive attached, 1-inch thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

      a. Cover liner with nonporous foil.
2. Air Inlet: Round stub connection for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Airflow Meter: Provide a multiple point averaging flow sensing ring with high and low pressure pneumatic tubes compatible with DDC velocity pressure sensor on each terminal unit inlet. A calibration chart shall be mounted on each terminal unit.
5. Access: Removable panels for access to diverting damper and other parts requiring service, adjustment, or maintenance; with airtight gasket.

C. Damper Assembly: Heavy gauge steel blades with solid steel shaft, with nylon-fitted pivot points

1. Maximum Damper Leakage: ARI 880 rated, 3 percent of nominal airflow at 6-inch wg inlet static pressure.
SECTION 15550 – BREECHINGS, CHIMNEYS, AND STACKS
PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. GENERAL

1. Stacks should be shown on the drawings using the standard fittings and pieces cataloged from the manufacturer. Stacks shall be drawn double line with joint lines drawn for each fitting or component.

2. Coordinate with the architect to maintain the required clearance to combustible materials.

3. Coordinate with the architect to maintain the required space to support the vertical stack in the chase using the cataloged supports.

4. Locate stack discharge such that the discharge is not drawn into fresh air intakes for the building or adjacent buildings. Prevailing winds and obstructions shall be considered.

5. Individual boiler flues are preferred. The designer shall pay close attention to flue layout and flue calculations. Flue draft fans are not acceptable.

6. Coordinate with Architect to conceal stacks.

B. B VENT

1. B Vent shall be double wall type. The vent shall have an inner wall constructed of a minimum of .018" thick aluminum alloy. The outer wall shall be a minimum of .020" of G-90 galvanized steel.

C. POSITIVE PRESSURE

1. The double wall stack shall have an outer jacket of a minimum of .025" thick aluminum coated steel. The inner gas carrying pipe shall be a minimum of .035" thick type 316 stainless steel.

2. The engineer shall determine the required insulation value based on the application and what is adjacent to the stack.

D. CONDENSING

1. Flue shall have AL29-4C stainless steel wall.
PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS

A. B Vent and Positive Pressure
   1. AMPCO
   2. Metalbestos
   3. Metal-Fab
   4. Schebler
   5. Van-Packer

B. Condensing
   1. Heat Fab, ProTech Systems, or equivalent

2.2 SPECIFICATIONS

A. Specify that the vendor provide flue calculations with shop drawing submittal.
SECTION 15990 – COMMISSIONING

PART I PROGRAMMING AND DESIGN GUIDELINES

1.1 PURPOSE

A. This document defines the different types of commissioning that may be used on a project and the roles of each person in the process.

B. The Owner shall instruct the design team if commissioning, and at what level, will be included in the project.

1.2 DEFINITIONS

A. Commissioning: The process of ensuring that systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent.

B. Commissioning Authority: The designated person, company, or agent who implements the overall commissioning process.

C. Design Intent: A detailed explanation of the ideas, concepts, and criteria that are defined by the owner to be important. This typically is an expansion of the information provided in the Owner’s program.

D. Field Installation Verification (FIV): The process of determining that equipment and systems have been installed properly and in accordance with the construction documents.

E. Functional Performance Test (FPT): The process of determining the ability of the equipment and systems to deliver performance, accordance with the final design intent.

1.3 TYPES OF COMMISSIONING

A. Fundamental: Design Professionals develop design intent. Near the end of construction the Commissioning Authority develops and completes FIV forms, and FPT forms. All major pieces of MEP equipment will be commissioned. Twenty-five percent of HVAC terminal equipment will be commissioned.

B. Enhanced: Starting at the beginning of the project the Commissioning Authority works with the Design Team and Owner. All major pieces of MEP equipment will be commissioned. All HVAC terminal equipment will be commissioned. Commissioning Authority can not be a member of the design firm.
SECTION 235216 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes packaged, factory-fabricated and -assembled, gas-fired condensing boilers, trim, and accessories for generating hot water.

1.2 DESIGN REQUIREMENTS

A. Heating hot water systems shall be designed with a maximum heating water supply temperature of 140°F. Design in this fashion reduces heat losses and ensures that the heating water system always operates in a range that will ensure flue gas condensation.

B. Heating hot water systems shall be designed in a variable flow, primary only pumped configuration. Boiler shutoff control valves shall be installed to stop the flow of hot water to offline boilers. If all boilers are offline, control logic shall force all boiler isolation valves full open.

C. Condensing boilers shall be capable of operation down to 15% of design water flow. Boilers shall be warranted to operate down to zero water flow without damaging the boiler.

D. Building automation via direct digital control shall be provided for boilers. Controls shall be arranged such that a boiler controller monitors and controls boiler staging, or that the building automation controls boiler staging. If a boiler controller is provided, this device shall be integrated to the building automation system. As a minimum, the following shall be monitored: Boiler entering and leaving water temperature, boiler status, boiler on/off command, boiler control valve command. As a minimum, the following control commands shall be accepted by the boiler from the building automation system: boiler supply water temperature setpoint, boiler enable / disable.

PART 2 - PRODUCTS

2.1 CONDENSING BOILERS

A. Description: Factory-fabricated, -assembled, and -tested, condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls.

B. Heat Exchanger: Stainless-steel primary and secondary combustion chamber.
C. Pressure Vessel: Carbon steel with welded heads and tube connections.

D. Burner: Natural gas, self-aspirating and self-venting after initial start. 15 to 1 turndown capability.

E. Blower: Centrifugal fan to operate only during start of each burner sequence. Boiler shall be configured for sealed combustion.
SECTION 15640 – PACKAGED COOLING TOWERS

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. Layout shall be arranged to facilitate cooling tower maintenance and good airflow. Where cooling tower connection sizes are smaller/larger than the line sizes associated with the system piping, a reducer/increaser shall be installed immediately at the cooling tower flanges to adapt to the indicated line size. All specialties and service valves associated with the cooling tower shall be line size, and not cooling tower connection size.

B. Cooling Towers shall be located on building roofs and shall be architecturally screened, including safety rails and headers, in the design of the building. The location of the cooling towers shall not be located above spaces sensitive to noise or vibration.

C. Cooling Tower selections shall meet the following criteria/options:
   1. High Efficiency.
   2. Low noise, maximum 65 dBA at the ground level and 50 dBA at the property line.
   3. 80°F Ambient wet bulb.
   4. 85°F leaving condenser water.
   5. Stainless steel or FRP hot and cold basins.
   7. TEFC motor outside of the air stream with a gear drive.
   8. Service platforms, plenum walkways, ladders and guardrails.
   9. Vibration switch
   10. Without makeup water valve and float assembly.

D. Cooling towers shall be directly attached to galvanized steel supports. Vibration isolation shall only be used where the designer demonstrates the need.

E. Inverters shall be used on cooling tower fans. Motors shall be inverter duty per NEMA MG-1, Part 31 (1600 volt peak, 0.1 microsecond rise time).

F. Cooling towers shall be designed with freeze protection. Consult Facilities Engineering to determine if heating will be by electric basin heaters and electric heat trace or by a side stream heat exchanger.

G. Where winter time operation of the condenser water is not expected, a single modulating bypass shall be provided between condenser water supply and return piping configured to enable cold startup of the chilled water system. In general, this control valve shall be located at an accessible location inside the chilled water plant. Where winter time operation is expected, in addition to the inside bypass, a two position (non-
modulating) bypass shall be installed to dump the flow capacity of one condenser water pump from the condenser water return to the common equalizer pipe. This valve is provided to allow for low load condenser water temperature control.

H. In general, cooling towers shall be sized to serve the maximum rated capacity of all the connected chillers, (including chillers that are considered redundant). One cooling tower cell shall serve a maximum of one chiller. It is acceptable to use more than one cooling tower cell to serve a single chiller.

I. Multi-cell towers shall be piped with an external equalizer line with valves in lieu of basin weir plate. Equalizer lines shall have a maximum pressure drop of 3 in. w.c. under worst case operating condition. Multi-cell towers shall have a magnetostrictive type water level sensor located in the equalizer piping.

J. The DDC shall control/monitor the following: fan speed control, water level sensor, modulating makeup water valve and vibration alarm switch.

K. Provide freezeless hose bibs near the cooling towers to allow cleaning.

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS

A. Cooling Towers shall be Baltimore Air Coil or Marley.

2.2 SPECIFICATIONS

A. Specify that the contractor is responsible for installing all components shipped loose with the cooling tower.

B. Specify that the tower manufacturer shall provide a representative during start-up to program/lockout of tower natural frequencies.

C. Life cycle bidding is the preferred method of purchasing Loop cooling towers.
SECTION 237312 – LABORATORY FAN COIL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Laboratory Fan Coil Units

1.2 DESIGN REQUIREMENTS

A. Project shall designed such that there is a minimum of 30 inches clearance on one side of the fan coil unit for maintenance access and filter changing. Drawings shall indicate the location of service clearance and shall illustrate that the clearance requirements be maintained. Access doors / panels that are removable without tools shall be provided at all maintenance access points.

B. Direct drive fans with variable speed drives for capacity control are preferred. Variance from this requirement must be approved in writing by the University.

C. Fan coil unit cooling coils shall have stainless steel frames and tube supports. Heating and cooling coils shall have fin spacing no greater than 10 fins per inch.

D. Fan coil unit casings shall be double wall insulated, minimum 2” thick wall construction.

E. Building automation via direct digital control shall be provided for laboratory fan coil units. Fan coil controls shall include fan start/stop, fan speed command, fan status (via current transducer), modulating cooling valve command, modulating heating valve command (where applicable) and supply fan discharge air temperature.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. McQuay
2. Trane
3. Temtrol
4. York
5. MagicAire
2.2 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Casing Joints: Sheet metal screws or pop rivets.
3. Sealing: Seal all joints with water-resistant sealant.
4. Factory Finish for Steel or Galvanized-Steel Casings: Apply manufacturer’s standard primer immediately after cleaning and pretreating.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Casing Insulation and Adhesive:

1. Materials: Exterior casing shall be minimum 18 Ga G90 galvanized sheet metal. Interior casing shall be minimum 20 Ga G90 galvanized sheet metal. Insulation shall be 1-1/2 lb per cubic feet density high density fiberglass or foam insulation.

C. Inspection and Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
2. Inspection and Access Panels:
   a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
   b. Gasket: Neoprene, applied around entire perimeters of panel frames.
   c. Size: Large enough to allow inspection and maintenance of air-handling unit’s internal components.
3. Access Doors:
   a. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from outside. Arrange doors to be opened against air-pressure differential.
   b. Gasket: Neoprene, applied around entire perimeters of panel frames.

D. Condensate Drain Pans:

1. Fabricated with two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
2. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
3. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
2.3 FANS

A. Refer to Fans Design Guide

2.4 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with ARI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. Cooling coils shall be provided with stainless steel frames and tube supports.
4. Coil fin spacing shall not exceed 10 fins per inch.

2.5 AIR FILTRATION SECTION

A. General Requirements for Air Filtration Section:

1. Comply with NFPA 90A.
2. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
3. Filters shall be disposable filters, minimum of nominal 2" thickness, MERV 8, no less than 15 pleats per foot.
4. Provide filter holding frames arranged for flat orientation, with access door on one side of unit.
SECTION 115300 – LABORATORY FUME HOODS

PART 1 - GENERAL

1.1 DESIGN REQUIREMENTS

A. Laboratory fume hood airflows (for new installations and for renovation projects) shall be designed based on a sash full open position of 14” for vertical sashes.

B. New laboratory fume hoods shall be specified to meet the performance requirements listed below.

C. Laboratory fume hoods that are ducted to variable volume exhaust air systems shall be provided with a pressure independent automatic flow control device (specified on mechanical drawings).

1.2 PERFORMANCE REQUIREMENTS

A. Containment: Provide fume hoods that comply with the following when tested according to ASHRAE 110 as modified below at a release rate of 4.0 L/min.:

1. Average Face Velocity: 70 fpm plus or minus 10 percent with sashes 14” high, 55 fpm with sashes 18” high, 55 fpm with sash fully open.

2. Face Velocity Variation: Not more than 10 percent of average face velocity.

3. Sash Position:
   a. Test hoods with combination sashes with maximum opening on one side, with maximum opening in the center, and with one opening at each side equal to half of maximum opening.
   b. Test hoods with combination sashes raised to 14” with horizontal windows closed.
   c. As-Manufactured (AM) Rating: AM 0.05 (0.05 ppm).
   d. As-Installed (AI) Rating: AI 0.05 (0.05 ppm).

4. Test Setup Modifications: Conduct tests with a minimum of 3 and a maximum of 5 people in the test room and with two 1-gal. round paint cans, one 12-by-12-by-12-inch cardboard box, and three 6-by-6-by-12-inch cardboard boxes in the fume hood during the test. Position items from 6 to 10 inches behind the sash, randomly distributed, and supported off the work surface by 2-by-2-inch blocks.

5. Walk-by Test: At the conclusion of containment test, execute 3 rapid walk-bys at 30-second intervals, 12 inches behind the manikin. Test-gas concentration during each walk-by shall not exceed 0.1 ppm and shall return to specified containment value within 15 seconds.
SECTION 15060 – HANGERS AND SUPPORTS

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. HANGERS
1. Pipe hangers, supports, etc. for “cold” piping systems shall have hangers sized for the outside diameter of the insulation in order to maintain a continuous vapor barrier.
2. Hangers, and other supports, anchors, guides, etc. in direct contact with copper piping material shall be copper plated with rubber coating. All others shall be electro-plated for indoor use and hot-dipped galvanized for outdoor use, tunnel use, and other corrosive areas such as natatoriums and pool equipment rooms.
3. Hangers 3’ and smaller shall be adjustable ring type. Hangers 4’ and larger shall be adjustable clevis type.
4. Roller hangers, saddles, guides/slides, and anchors shall be designed and shown for pipe expansion/contraction.
5. Vertical piping shall be supported at each floor level with riser clamps bearing on the building structure or pipe sleeve.
6. Pipe shields shall be used on insulated piping.
   a. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
   b. For Trapezoid or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

B. SUPPORTS
1. Indicate pipe supports where piping is not hung from above or where require to take weight off of equipment connections.
2. Where pipe stands are not on a housekeeping pad, the base plate shall be spaced 1” minimum above the finished floor with concrete or grout used to fill the void.

C. HANGER RODS
1. All-thread rod used indoors shall be cadmium or zinc electro-plated, and hot-dipped galvanized for outdoor use, tunnel use, and other corrosive areas such as natatoriums and pool equipment rooms.

D. ANCHORS
1. In all cases, anchor loading shall be based on hanger spacing, weight of the pipe system, contents, insulation, test water, weight of any additional loads imposed upon the anchor, wind loading, seismic loading, quality of the material that the anchor is being installed in, etc.
2. Power driven inserts and attachments are not permitted.
3. In new concrete construction mechanical equipment rooms shall have cast in place inserts placed at a maximum of 4 ft. on center each way.
4. In buildings with steel framing anchors shall be attached to the steel by bolting directly through the void in the bar joist chord or by using the appropriate cataloged type C-clamp or beam clamp. Metal or wood roof decks shall not be used for supporting the piping, ductwork, or equipment.

E. EQUIPMENT PADS
1. Floor mounted equipment shall be located on concrete housekeeping pads. Typical height of 3-1/2 inches with chamfered edges and corners.

2. Equipment pad size shall include required edge spacing for anchor bolts and seismic forces. Reinforcing shall be designed in accordance with ASHRAE Practical Guide to Seismic Restraint or designed by a structural engineer.

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 SPECIFICATIONS

A. Coordinate project specification with the requirements of Part 1.

2.2 CONCRETE INSERTS

A. DRAWINGS

1. Clearly identify on mechanical drawings the areas that cast in place inserts are required. If there is a particular layout that is required, then show a detailed layout on the drawings.

2. Coordinate with Structural Engineer to note on structural drawings the areas of cast in place inserts.

B. SPECIFICATIONS

1. Specify cast in place in place anchors in the Hanger and support section of the specification. This section should specify the material and provide the spacing/layout requirements.

2. Coordinate with Architect the Concrete specification scope of work. Division 3 should include the installation of the inserts.
SECTION 235700 - HEAT EXCHANGERS FOR HVAC

PART 1 - PROGRAMMING AND DESIGN GUIDELINES

1.1 SUMMARY

A. Section includes shell-and-tube and plate heat exchangers.

1.2 DESIGN REQUIREMENTS

A. Shell and tube heat exchangers shall be used in lieu of plate frame style heat exchangers whenever practical.

B. For steam to hot water heat exchangers, heat exchanger shall be designed to be mounted at an elevation that will permit gravity draining of condensate back to building condensate pump. Condensate shall not be “lifted”.

C. Where failure of a heat exchanger will result in more than one hour of disruption to University operations, a backup heat exchanger shall be specified. The heat source for duplex heat exchangers shall be piped in a manifold such that failure of a control valve will not cause one heat exchanger to be removed from service. Shutoff valves shall be provided for each heat exchanger downstream of the control valve manifold.

D. Heat exchangers shall be designed such that there is adequate clearance to remove tube bundles / rebuild plate heat exchangers. Drawings shall indicate the location of service clearance and shall illustrate that the clearance requirements can be maintained.

PART 2 - BIDDING AND CONTRACT DOCUMENT REQUIREMENTS

2.1 SHELL-AND-TUBE HEAT EXCHANGERS

A. Description: Packaged assembly of tank, heat-exchanger coils, and specialties.

B. Construction:

1. Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.
2. Fabricate and label shell-and-tube heat exchangers to comply with "TEMA Standards."


D. Shell Materials: Steel.
E. Head:
   1. Materials: Cast iron
   2. Flanged and bolted to shell.

F. Tube:
   1. ⅜" Seamless copper tubes.

G. Tubesheet Materials: Brass or Stainless steel

H. Baffles: Brass or Stainless steel

I. Piping Connections: Factory fabricated of materials compatible with heat-exchanger shell. Attach tappings to shell before testing and labeling.
   1. NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
   2. NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

2.2 GASKETED-PLATE HEAT EXCHANGERS

A. Configuration: Freestanding assembly consisting of frame support, top and bottom carrying and guide bars, fixed and movable end plates, tie rods, individually removable plates, and one-piece gaskets.

B. Construction: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.

C. Frame:
   1. Capacity to accommodate 20 percent additional plates.
SECTION 233416 - HVAC FANS

PART 1 - PROGRAMMING AND DESIGN GUIDELINES

1.1 SUMMARY

A. Section includes the following fan types:
   1. Air handling units fans
   2. Exhaust fans including laboratory exhaust fans
   3. Return fans
   4. Relief fans
   5. Laboratory fan coil unit supply fans

1.2 DESIGN REQUIREMENTS

A. Fans shall be licensed to bear the AMCA Performance Air and Sound Certified Rating Seal. Fans do not bear the AMCA seal shall not be specified and shall not be acceptable.

B. Fan class shall be sized with a 20% safety factor for speed to allow for future changes in airflow or pressure requirements.

C. Fans that modulate airflow shall utilize variable frequency drives to modulate capacity. Inlet vanes, outlet dampers, variable pitch blades, etc shall not be utilized for capacity control.

D. For belt driven fans, fans shall be specified to be provided with variable pitch sheaves for motor sizes 5 HP and less. As part of balancing, all sheaves shall be replaced with fixed pitch sheaves of the appropriate size as determined in the final balancing. The sheaves shall be set such that the fan is at the maximum speed at 60 HZ. Fan shall be capable of operating at 60 HZ without overloading.

E. For direct drive fans, fan speed shall be limited in balancing through the setup of the VFD to the maximum fan speed required to deliver design airflow.

F. Fan motor shall be sized such that the fan operates below the service factor.

PART 2 - PRODUCTS

2.1 FANS

A. Description:
1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven or direct-drive fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.

B. Wheels: Select the most efficient wheel style (airfoil, backward inclined or forward curve, etc that is offered for fan style)

C. Shafts:
   1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
   2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
   3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

D. Grease-Lubricated Shaft Bearings:
   1. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
   2. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours.
   3. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours.

E. Belt Drives:
   1. Factory mounted, with adjustable alignment and belt tensioning.
   2. Service Factor Based on Fan Motor Size: 1.5.
   3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
   4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range in fan design conditions.
   5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   6. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

F. Accessories:
2. Scroll Drain Connection: NPS 1 steel pipe coupling welded to low point of fan scroll.
SECTION 15156 – CLEANING OF PIPING SYSTEMS

PART 1 PROGRAMMING AND DESIGN GUIDELINES

CHEMICAL TREATMENT

A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:

1. pH: 9.0 to 10.5.
2. "P" Alkalinity: 100 to 500 ppm.
3. Boron: 100 to 200 ppm.
4. Chemical Oxygen Demand: Maximum of 100 ppm.
5. Corrosion Inhibitor:
   a. Sodium Nitrate: 1000 to 1500 ppm.
   b. Molybdate: 200 to 300 ppm.
   c. Chromate: 200 to 300 ppm.
   d. Sodium Nitrate Plus Molybdate: 100 to 200 ppm each.
   e. Chromate Plus Molybdate: 50 to 100 ppm each.

6. Soluble Copper: Maximum of 0.20 ppm.
7. Tolybrazole Copper and Yellow Metal Corrosion Inhibitor: Minimum of 10 ppm.
8. Total Suspended Solids: Maximum of 10 ppm.
11. Microbiological Limits:
   a. Total Aerobic Plate Count: Maximum of 1000 organisms/mL.
   b. Total Anaerobic Plate Count: Maximum of 100 organisms/mL.
   c. Nitrate Reducers: 100 organisms/mL.
   d. Sulfate Reducers: Maximum of zero organisms/mL.
   e. Iron Bacteria: Maximum of zero organisms/mL.

B. Install bypass chemical feeders in each hydronic system where indicated.

1. Install in upright position with top of funnel not more than 48 inches above the floor.
2. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections.
3. Install NPS 3/4 pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port, ball valve.
C. Clean piping system as follows:

1. Flush system with water until water runs clean from all drain locations.
2. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer, and screens.
3. Flush system with clean water to rinse of cleaning solution while draining at all low points.
4. Fill system with clean water.

D. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

E. Fill systems that have antifreeze or glycol solutions with the following concentrations:

1. Hot-Water Heating Piping: Minimum of 50% percent propylene glycol which correlates to minus 20 degrees F
2. Chilled-Water Piping: Minimum of 50% percent propylene glycol which correlates to minus 20 degrees F
3. Dual-Temperature Heating and Cooling Water Piping: Minimum of 50% percent propylene glycol which correlates to minus 20 degrees F
4. Glycol Cooling-Water Piping: Minimum of 50% percent propylene glycol which correlates to minus 20 degrees F

FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.

4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

6. Prepare written report of testing.
SECTION 15075 –MECHANICAL IDENTIFICATION

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 GENERAL

A. Valve tag and equipment identification information is required on “as-built” drawing submittals.

B. When adding equipment within an existing building the drawings shall use the same numbering scheme as the existing building and use the next number in the equipment series. Using equipment number xyz-1 must be avoided. Coordinate with the Owner.

1.2 EQUIPMENT IDENTIFICATION

A. All major equipment items (i.e., chillers, air handling units, fans, terminal units, pumps, boilers, etc.) shall be identified with appropriately sized nameplates permanently attached to the respective equipment.

B. Small equipment items (i.e., in-line pumps, pot feeders, etc.) shall be identified with brass valve tags, see requirements for valve tags and chains.

C. Equipment that is controlled by the Building Automation Control System shall be labeled with a 2” x 5” red label with white letters:

“CAUTION – THIS EQUIPMENT IS UNDER COMPUTER CONTROL AND MAY CYCLE AT ANY TIME.”

D. Interior equipment nameplates shall be 1/16” thick two-ply acrylic plastic 2-1/2” x 1” size minimum with white letters on a black background. Tag size shall be appropriate for equipment name, letters shall be a minimum of ½” high.

E. Exterior equipment shall be identified with nameplates suitable for exterior use or shall be engraved aluminum plates .020” thick, minimum size shall be 4” x 1-1/2” plates.

F. Nameplates shall be attached with corrosion-resistant No. 3 round head or No. 4 sheetmetal screws.

G. The following legend shall be used:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Handling Unit</td>
<td>AHU</td>
</tr>
<tr>
<td>Air Dryer</td>
<td>AD</td>
</tr>
<tr>
<td>Air Cooled Condenser</td>
<td>ACC</td>
</tr>
<tr>
<td>Back Flow Preventer</td>
<td>BFP</td>
</tr>
<tr>
<td>Boiler</td>
<td>B</td>
</tr>
<tr>
<td>Booster Pump</td>
<td>BP</td>
</tr>
<tr>
<td>Chiller</td>
<td>CHL</td>
</tr>
<tr>
<td>Chilled Water Pump</td>
<td>CWP</td>
</tr>
</tbody>
</table>
Climate Room CR
Condensate Pump CONP
Constant Volume Box CV
Control Air Compressor CA
Cooling Tower CT
DI Water System DI
DI Water Pump DIP
Domestic Cold Water Pump DCP
Domestic Hot Water Heater DHH
Domestic Hot Water Pump DHP
Drinking Fountain DF
DX Unit DX
Elevator ELV
Emergency Generator EMG
Emergency Eyewash & Shower Wash EW
Exhaust Fan EXF
Fan Coil Unit FC
Fire System FS
Fire Pump FP
Fume Hood FH
Heat Exchanger HE
Heating Water Pump HWP
Jockey Fire Pump JFP
Lab Air Compressor LA
Pre-Heat Pump PHP
Reclaim Pump RCP
Re-Heat Pump RHP
Return Fan or Relief Fan RAF
Reverse Osmosis Unit ROU
Rooftop Unit RTU
Steam System STS
Steam Condensate Receiver CRU
Steam Trap ST
Still STL
Sump Pump SUMP
Supply Fan SF
Transformer TRF
Unit Heater UH
Variable Air Volume Box VAV
Vacuum Pump VCP
Variable Frequency Drive VFD
Water Treatment WT

Note: All above Equipment Names and Abbreviations should have a building code prefix. Example: An Air Handling Unit for the Genome Data Center would be...GDCAHU1...

1.3 PIPING IDENTIFICATION

A. The following schedule shall govern label types for each application:

<table>
<thead>
<tr>
<th>Location</th>
<th>Type</th>
</tr>
</thead>
</table>


1. Type I - Vinyl pressure sensitive tape color coded and lettered for label of service. Flow direction shall be separately labeled with 2" wide pressure sensitive tape. The flow arrow band shall overlap the service label to secure it in place and shall not be less than two complete wraps around the pipe.

2. Type II - Semi-rigid plastic, pre-formed to fit curvature of pipe or pipe insulation, color coded and imprinted with media identification and flow direction. Available in varied sizes for pipe diameter, wording and inclusion of arrow.

3. Type III - Non-vinyl chloride markers specifically design for outdoor use.

4. Type IV - Continuous 6" wide x 0.004" polyethylene film, color coded, and imprinted for type of utility buried below located in the same trench as the piping and/or utility and positioned approximately 12" above the top of the utility.

5. Type V - Continuous 6" wide x 0.035 metallic detection tape, color coded and imprinted for type of utility buried below located in the same trench as the piping and/or utility and positioned approximately 12" above the top of the utility.

B. Markers shall be installed in clear view, located at not more than twenty-five foot (25') intervals on straight runs at all branch locations; and located on each side of penetrations of the building structure and non-accessible enclosures.

C. The following legend, color, and lettering shall be used for above ground and indoor piping:

<table>
<thead>
<tr>
<th>Service and Legend</th>
<th>Color of Field</th>
<th>Letters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials Inherently Hazardous:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Acid Waste</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>High Press. Compressed Air (over 90 psig)</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Boiler Blowdown</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Boiler Feedwater</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Hot Water Supply</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Hot Water Return</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Low Pressure Steam</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Low Pressure Steam Condensate</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Medium Pressure Steam</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Medium Pressure Steam Condensate</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>High Pressure Steam</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>High Pressure Steam Condensate</td>
<td>Yellow</td>
<td>Black</td>
</tr>
<tr>
<td>Pumped Condensate</td>
<td>Yellow</td>
<td>Black</td>
</tr>
</tbody>
</table>
### Refrigerant
- Yellow
- Black

### Domestic Hot Water
- Yellow
- Black

### Domestic Hot Water Return
- Yellow
- Black

### Waste
- Yellow
- Black

### Vent
- Yellow
- Black

### Materials of Inherently Low Hazard:
- **Chilled Water Supply**
  - Green
  - White
- **Chilled Water Return**
  - Green
  - White
- **Cold Water**
  - Green
  - White
- **Condenser Water Supply**
  - Green
  - White
- **Condenser Water Return**
  - Green
  - White
- **Drain**
  - Green
  - White
- **Roof Drain**
  - Green
  - White

### Fire Quenching Materials:
- **Sprinkler – Fire**
  - Red
  - White

#### D. The following legend, color, and lettering shall be used for below ground piping:

<table>
<thead>
<tr>
<th>Service</th>
<th>Color</th>
<th>Legend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sewer</td>
<td>Green</td>
<td>Caution Buried Sewer</td>
</tr>
<tr>
<td>Potable Water</td>
<td>Blue</td>
<td>Caution Buried Water</td>
</tr>
<tr>
<td>Non-potable Fire (S. 40)</td>
<td>Purple</td>
<td>Caution Buried Reclaimed Water</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Yellow</td>
<td>Caution Buried Gas</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>Yellow</td>
<td>Caution Buried Fuel</td>
</tr>
<tr>
<td>Steam</td>
<td>Yellow</td>
<td>Caution Buried Utility Line</td>
</tr>
<tr>
<td>Chilled Water</td>
<td>Purple</td>
<td>Caution Buried Reclaimed Water</td>
</tr>
<tr>
<td>Condenser Water</td>
<td>Purple</td>
<td>Caution Buried Reclaimed Water</td>
</tr>
<tr>
<td>Heating Water</td>
<td>Purple</td>
<td>Caution Buried Reclaimed Water</td>
</tr>
<tr>
<td>Condensate</td>
<td>Purple</td>
<td>Caution Buried Reclaimed Water</td>
</tr>
<tr>
<td>Irrigation Water</td>
<td>Purple</td>
<td>Caution Buried Reclaimed Water</td>
</tr>
</tbody>
</table>

### 1.4 VALVE IDENTIFICATION

A. All valves exposed or concealed shall be identified with brass valve tags indicating the service of system the valve is in and the number of the valve.

B. Valve tags shall be minimum 1-1/2" diameter brass stock with ¾" legend identifying and ⅜" valve number both shall be black enamel filled. Legends shall be HVAC, PLBG, SPR, and GAS.

C. Valve tags shall be secured in place with a No. 6 brass bead chain or No. 16 brass jack chain. Chains shall be attached to the valve lever handle or around the valve stem.

D. Valve tags located above lay-in ceilings shall be hung where the valve tag hangs below the level of the piping so that they are easily located.

### 1.5 DUCTWORK IDENTIFICATION
A. Supply, return and exhaust ductwork uninsulated or insulated, exposed or concealed, shall be identified as specified herein, except for exposed ductwork in finished areas.

B. Markers shall be installed in clear view; installed on both sides of the duct; run parallel to the ductwork; located at not more than twenty-five foot (25') intervals on straight runs at all branch locations; and located on each side of penetrations of the building structure and non-accessible enclosures.

C. Markers shall be pressure sensitive vinyl tape labeled for service and direction of airflow. Minimum size shall be 2" high x 8" long.

D. Supply, return, exhaust and outdoor air ductwork labels shall be blue with white letters. Outdoor air ductwork labels shall be blue with white letters have an "air" or "outdoor air" legend. Hazardous exhaust air ductwork labels shall be yellow with black letters.
SECTION 15620 – PACKAGED WATER CHILLERS

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. Layout shall be arranged to facilitate chiller maintenance. Piping shall be arranged so that the service valves can be closed and the piping and specialties between the service valves and chiller can be removed for servicing and to allow clear access to the water boxes for removal as required. Flanges or victaulic couplings shall be located to allow removal of a minimal amount of piping to clean the chiller tubes. Where chiller connection sizes are smaller/larger than the line sizes associated with the system piping, a reducer/increaser shall be installed immediately at the chiller flanges to adapt to the indicated line size. All specialties and service valves associated with the chiller shall be line size, and not chiller connection size.

B. Chillers shall be located at grade or basement level on an exterior wall for easy replacement without disassembling the chiller or without removing ductwork or piping. Chillers located at grade shall have an overhead door, removable louver, or removable panel. Chillers located below grade shall have an area way.

C. Head room and piping layout shall allow removal of the chiller compressor and motor with an A frame hoist.

D. Loop Chiller selections shall meet the following criteria:
   1. Centrifugal compressor.
   2. High Efficiency, complies with ASHRAE 90.1
   3. HCFC-123 or HFC-134a refrigerant.
   4. 44°F leaving water temperature, fouling factor 0.00025.
   5. 85°F entering condenser water, fouling factor 0.0005.
   6. Evaporator flow based on a 12degree F temperature drop.
   7. Refrigerant rupture disk and refrigerant relief valve in series to minimize charge loss on an over pressure condition. A pressure switch shall be located between the two devices to indicate a ruptured disk.

E. Process Chiller selections shall meet the following criteria:
   1. Scroll or screw compressor.
   2. HFC-134a , HFC-407c refrigerant.
   3. Evaporator fouling factor 0.00025.
   4. Air cooled condensers selected at 105°F ambient for summer operation.
   5. Air cooled condensers selected at 0°F ambient for winter operation.
   6. 85°F entering condenser water, fouling factor 0.0005.

F. Chillers installed at slab on grade shall be installed on a neoprene pad. Vibration isolation shall only be used where the designer demonstrates the need.
G. Chiller pad shall be reinforced and doweled to the floor to withstand seismic forces. Chiller attachment to the pad shall withstand seismic forces. The drawings shall indicate the specific requirements, including snubber size, anchor bolt size, embedment depths, edge distance requirements, anchor spacing requirements.

H. Refrigerant relief piping shall be copper or steel with a braided flexible connector at the chiller connection.

I. Provide an electric kW meter with each chiller. In general the chiller should be metered at the 5 kV load switch in lieu of the chiller starter.

J. Loop chillers shall be Johnson Controls N2 compatible or the manufacturer shall provide a gateway to the Johnson Controls system. If a gateway is to be provided show the gateway panel location, power wiring to the panel, and communication wiring between the gateway and the chiller.

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS

A. Centrifugal Loop Chillers shall be Trane, York, and Carrier.

B. Process Chillers shall be Trane, York, Carrier, and McQuay.

C. Electronic Flow Switches shall be Ameritrol, Inc. model FM-0750-voltage-02-S.

2.2 SPECIFICATIONS

A. Specify that chiller be Johnson Controls N2 compatible or the manufacturer shall provide a gateway to the Johnson Controls system. The manufacturer shall include the cost of field programming and mapping the gateway points.

B. Include temperature control point to monitor the pressure switch between the refrigerant rupture disk and relief valve.

C. Specify that the chiller condenser water tubes be Eddy Current tested, at the job site after installation, and that the test data be submitted to the Owner.

D. Specify that the chiller warranty be five (5) years from Substantial Completion.

E. Specify Contractor to adjust set point for electronic flow switches.
F. Life cycle bidding is the preferred method of purchasing Loop chillers. Life cycle cost should be based on 7 years of expected energy consumption for the chiller and auxiliaries.
SECTION 234100 - PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Pleated panel filters.
   2. V-bank cell filters.
   3. Rigid cell filters
   4. Front- and rear-access filter frames.
   5. Side-access filter housings.
   6. Filter gages.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.
   1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
   2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
   3. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Provide one complete set(s) of filters for each filter bank. If system includes prefilters, provide only prefilters.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:
   1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
   2. Comply with ASHRAE 52.1 for air resistance and ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.

C. Comply with NFPA 90A and NFPA 90B.

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

PART 2 - PRODUCTS

2.1 GENERAL

A. Manufacturers: The housings, frames and filters shall be by the same manufacturer. Subject to compliance with requirements, provide products by one of the following:
   a. AAF International
   b. Camfil Farr
   c. Flanders-Precisionaire
   d. Koch Filter Corporation

B. All filter applications shall be as per the schedule herein.

2.2 PLEATED PANEL FILTERS

A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.

B. Filter Unit Class: UL 900, Class 2.

C. Media: Cotton and synthetic fibers.
   1. Separators shall be bonded to the media to maintain pleat configuration.
   2. Welded wire grid shall be on downstream side to maintain pleat.
3. Media shall be bonded to frame to prevent air bypass.
4. Support members on upstream and downstream sides to maintain pleat spacing.

D. Filter-Media Frame: Cardboard frame with perforated metal retainer sealed or bonded to the media.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

F. Capacities and Characteristics:
   1. Face Dimensions: 24 inches x 24 inches.
   2. Thickness or Depth: 2 inches.
   3. Number of Filters: As Required.
   4. Maximum or Rated Face Velocity: 500 FPM.
   5. Efficiency: 90 percent on particles 20 micrometers and larger at 500 fpm.
   6. Initial Resistance: .28 inches w.g. at 500 fpm.
   7. Recommended Final Resistance: 1.0 inch w.g.
   8. MERV Rating: 8 when tested according to ASHRAE 52.2.

2.3 V-BANK CELL FILTERS

A. Description: Factory-fabricated, disposable, packaged air filters with media angled to airflow, and with holding frames.

B. Filter Unit Class: UL 900, Class 2.

C. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.

D. Filter-Media Frames: Hard polyurethane foam.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

F. Capacities and Characteristics:
   1. Face Dimensions: 24 inch x 24 inch.
   2. Thickness or Depth: 12 inches.
   3. Maximum or Rated Face Velocity: 500 FPM.
   4. Arrestance: 98 percent when tested according to ASHRAE 52.1.
   5. Initial Resistance: 0.27 inch w.g.
   6. Recommended Final Resistance: 0.60 inch w.g.
   7. MERV Rating: 13 or 14 as scheduled when tested according to ASHRAE 52.2.

2.4 RIGID CELL BOX FILTERS

A. Description: Factory-fabricated, disposable, packaged air filters with media perpendicular to airflow, and with holding frames.

B. Filter Unit Class: UL 900, Class 2.
C. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.

D. Filter-Media Frames: Galvanized steel.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

F. Capacities and Characteristics:
   1. Face Dimensions: 24 inch x 24 inch.
   2. Thickness or Depth: 12 inch.
   3. Maximum or Rated Face Velocity: 500 fpm.
   4. Arrestance: 98 percent when tested according to ASHRAE 52.1.
   5. Initial Resistance: 0.53 inch w.g.
   6. Recommended Final Resistance: 1.0 inch w.g.
   7. MERV Rating: 13 or 14 as scheduled when tested according to ASHRAE 52.2.

2.5 FRONT- AND REAR-ACCESS FILTER FRAMES

A. Description: Filter frames for use in built-up or field erected custom air handling units.

B. Framing System: Aluminum framing members with access for either upstream (front) or downstream (rear) filter servicing, cut to size and pre punched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.

C. Prefilters: Incorporate a separate track with spring clips, removable from front or back.

D. Sealing: Factory-installed, positive-sealing device for each row of filters, to ensure seal between gasketed filter elements and to prevent bypass of unfiltered air.

2.6 TWO-STAGE SIDE-SERVICE HOUSINGS

A. Description: Factory-assembled, side-service weatherproof housings, constructed of galvanized steel or aluminum with flanges to connect to duct or casing system.

B. Integral aluminum tracks shall accommodate 2-inch-deep prefilter, and either 12-inch deep rigid filter or pocket filter with header.

C. Dual Access Doors: Hinged, with continuous gaskets on perimeter and positive-locking devices, and arranged so filter cartridges can be loaded from either access door.

D. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames and to prevent bypass of unfiltered air.

E. Housing shall include pneumatic fittings to allow installation of static pressure gauge to evaluate pressure drop across a single filter or any combination of installed filters.
2.7 FILTER GAGES

A. Diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Dwyer Instruments, Inc.

2. Diameter: 4-1/2 inches.

3. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg or Less: 0- to 4.0-inch wg.

B. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

B. Install filters in position to prevent passage of unfiltered air.

C. Install filter gage for each filter bank.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

E. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

F. Coordinate filter installations with duct and air-handling-unit installations.

3.2 CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

3.3 SCHEDULE

A. Subject to coordination with the Owner and applicable Codes, filters shall be furnished in accordance with the following schedule:
B. General Purpose Air Handling Applications:
   1. Prefilter: None
   2. Final Filter: Pleated Panel Filters, MERV 8
   3. Location: Upstream of all coils and fans in units.

C. Laboratory Air Handling Applications:
   1. Prefilter: Pleated Panel Filters, MERV 8
   2. Final Filter: V-Cell or Rigid-Cell, MERV 13
   3. Location: Upstream of all coils and fans in units

D. Medical Air Handling Applications (Procedures, Treatment, or Operating Rooms):
   1. Prefilter: Pleated Panel Filters, MERV 8
   2. Final Filter: V-Cell or Rigid-Cell, MERV 14
   3. Location: Prefilter to be upstream of all coils and fans in unit and final filter
to be downstream of all coils and fans in unit.
SECTION 15130 – PUMPS

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. Piping at pumps shall be arranged to facilitate pump maintenance. Piping shall be arranged so that the service valves can be closed and the piping and specialties between the service valves and pump removed for servicing and to allow clear access to the pump for removal as required. Where pump connection sizes are smaller than the line sizes associated with the suction and discharge piping, reducer/increaser shall be installed immediately at the pump flanges to adapt to the indicated line size. All specialties and service valves associated with the pump such as strainers, check valves, etc., shall be line size, and not pump connection size.

B. In general 100% stand-by pumps shall not be used. Parallel pumps shall be used where added reliability is needed. Parallel pumps shall be selected at half the system flow at system head.

C. Pumps selections shall meet the following criteria:
   1. High Pump Efficiency.
   2. Mid range impeller size in the pump body.
   3. Non-overloading motor size for the impeller size.
   4. Parallel pumps shall not be off of the manufacturer’s published curve when operating on a single pump.
   5. The preference is 1750 RPM, then 1150 RPM, and then 3500 RPM.

D. Pumps installed at slab on grade shall not have inertia isolation bases. Inertia isolation bases shall only be used where the designer demonstrates the need.

E. Accurate pump head calculation and selection is required. The DESIGNER will pay to have the impeller trimmed for pumps that operate at design flow with a head 10 feet less than scheduled, or pay the cost to install a larger impeller where the pump flow is less than design flow.

F. Pump motors shall be NEMA Premium efficiency.

G. Pump coupling shall be rated for inverter use.

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS

A. Centrifugal pumps shall be Bell and Gossett.
2.2 INSTALLATION

A. Where existing systems are modified, specify that the Contractor install start-up strainers for existing pumps. Start-up strainers shall be removed after 72 hours of operation.

B. Specify that the start-up strainers shall be attached to the pump service valve after removal to show that the start-up strainer was removed.

2.3 EQUIPMENT SUBSTITUTION – BIDDING AND SHOP DRAWING REVIEW

A. Specify the following:
Where pumps are from manufacturers not scheduled the following criteria shall apply:

- High Pump Efficiency. Selections with pump efficiencies 5% less than the scheduled pump may be rejected.

- Mid range impeller size in the pump body. Selections with impellers near the smallest or largest size may be rejected.

- Non-overloading motor size for the impeller size. Selections with overloading motors may be rejected.

- Parallel pumps shall not be off of the manufacturer’s published curve when operating on a single pump. Selections off of the published curve may be rejected.
SECTION 15630 – REFRIGERANT MONITORING SYSTEMS

PART 1 PROGRAMMING AND DESIGN GUIDELINES

1.1 DESIGN REQUIREMENTS

A. Refrigerant monitors shall be infrared (IR) sensor technology. It shall accurately provide sensing down to 1 part per million (ppm).

B. Provide a refrigerant sensor on each side of the chiller. Chillers next to each other may share a common sensor if the refrigerants are the same.

C. Exhaust shall be ducted down to 12 inches above the mechanical room floor. The exhaust duct and makeup air inlet shall be located to “sweep” the room across the chiller.

D. An interposing relay shall be provided on the high alarm contact. The relay shall: start the exhaust fan, output to the DDC, and shut down any boilers in the same equipment room. These functions shall be hardwired and shall be shown on the electrical drawings.

E. The DDC shall monitor the following: low alarm level contact and high alarm level contact.

PART 2 BIDDING AND CONTRACT DOCUMENT GUIDELINES

2.1 MANUFACTURERS


2.2 SPECIFICATIONS

A. Specify the following alarm levels: The first level of alarm shall be set at 100 ppm (except for R-123, it shall be 20). The second level of alarm shall be set at the TLATWA level of 1000 ppm (except for R-123 which is 30 ppm).